J. Indian Soc. Coastal agric. Res., 4(1) 25-41, 1986

On the Culture of *Macrobrachium rosenbergii* (De Man) in Andhra Pradesh—India

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In Andhra Pradesh, India, large acreage of freshwater ponds seasonal, and perennial, have now been brought under freshwater fish cultivation. Large acreage traditionally under paddy cultivation also are being converted to fish farming using composite fish culture methods. Some of them can shift to freshwater prawn farming or partially incorporate, in separate monoculture of the species.

Macrobrachium rosenbergii has extensive natural fishery in some of the lakes and rivers but natural seed availability is not only rare but scarce too. Since 1970 techniques for hatchery rearing of post larvae have been developed by research organisations. Supply of stockable juveniles commenced by late 1970s.

The present study deals with experiments on post-larval production in small scale hatchery, costs of production, feed formulation using tubificid worms, water quality and survival. Experimental culture conducted in larger ponds with varying water and soil qualities, feeds growth and ultimate returns are also shown.

Incorporation of the species into mono or polyculture with fish in extensive system has a tremendous potential if a steady juvenile production is maintained. Thus, educating farmers on specific technologies, a good marketing system could lead to quick adoption by farmers to this extensive freshwater prawn farming of the fast-growing species such as *Macrobrachium rosenbergi* and the smaller riverine prawn of India, *Macrobrachium malcolmsonii*

Macrobrachium rosenbergii (De Man), the giant freshwater prawn is most common in the estuarine regions of the rivers both on East and West coasts of India, and in the Hooghly estuary in the North East. Chopra (1943), reported on the breeding habits of the species in South-West coast of India while John (1957), studied the fecundity potential and breeding migrations of the species in the same region. Rajyalakshmi (1961) for the first time, used ova-dimensions as a means of determining maturation and breeding periodicity in *Macrobrachium rosenbergii* and made observations on the salinity requirements for hatching in rivers. Raman (1967), made observations on breeding migrations and feeding of the species in the South-West coast of India. Rao (1967) studied the mating behaviour, breeding biology and age and growth of *Macrobrachium rosenbergii* of Hooghly estuary. Rajyalakshmi (1975), reported for the first time, the occurence of the species and its size composition in capture fisheries of certain paddy field drain channels opening into Kakinada Bay, in Andhra Pradesh.

Elsewhere in the world, with the studies conducted by Ling (1962, 1967 a

and 1967 b) in Malaysia and Fujimura (1966), Fujimura and Okomoto (1970), Fujimoto *et al.*, (1977) in Hawaii. considerable progress has been made on the culture aspects of the species such as production of juveniles, growth and production in grow-out ponds. An extensive review of work in United States of America has been given by various authors (Mayers 1974, Hagood and Willis 1976, Hanson and Goodwin 1977, among others) and that in United Kingdom (Wickins. 1978).

As compared to capture fisheries, the controlled production of juveniles and culture of *Macrobrachium rosenbergii* in freshwater ponds has received very little attention in India till 1970s (Rajyalakshmi, 1978). However, over a long time the species has been in extensive production in the freshwater impoundments of river Hooghly, at *Itindaghat*, in North-Eastern India. The juvenile stock is naturally recruited in these impoundments (Rajyalakshmi, unpublished doctoral thesis). In Andhra Pradesh, particularly, another large species of *Macrobrachium* viz., *M. malcolmsonii* has been introduced in experimental culture studies since 1968 in view of large natural stock of juveniles occuring at all the barriers (wiers) of rivers in this state (Ibrahim, 1962, Rajyalakshmi 1968 and 1972, and Rajyalakshmi *et al.*, 1982). Discovery of brood prawns of *Macrobrachium rosenbergii* in the paddy field drain channels which open in to the Kakinada Bay (Fig. 1) has led to an establishment of a small scale hatchery by the Central Inland Fisheries Research Institute (Anon, 1975 and 1976).

During the period 1975 to 1982 extensive grow-out ponds for fresh water fish have been excavated both in public and private sectors of Andhra Pradesh, the farm sizes ranging from 10 ha to 200 ha. Under these set of conditions incorporation of a variety, like the indigenous varieties of freshwater prawns in mixed culture has been receiving considerable attention. Fish farmers have now a growing awareness of the suitability of the giant prawn in this system. The demand for seed has gone up in 1980s. Keeping these points in view a few preliminary studies conducted by the authors since 1982 on hatchery production of juveniles and their introduction in different types of freshwater ponds, their growth and survival, potential for large scale introduction in farmers' ponds *etc.*, are discussed in this paper.

MATERIAL AND METHODS

Reproductive Biology and Brood Prawns

The maturity and breeding cycle of *Macrobrachium rosenbergii* have been well documented (Rajyalakshmi, 1961, and unpublished doctoral thesis 1976, Rao, 1967). In North-Eastern part or India females in berry are found from November and December to May and June. In peninsular India the maturity

and breeding commences from October and extends upto following June. Generally, berried females are found all the year round. As early as 1961, it was recorded that females need to migrate to tidal regions of the estuaries for hatching their larvae. The minimum size noted at maturity was 136 mm (total length). The females have a fecundity potential of 7000 to 1,11,400 in a size range of 136 to 250 mm (Rajyalakshmi, MS).

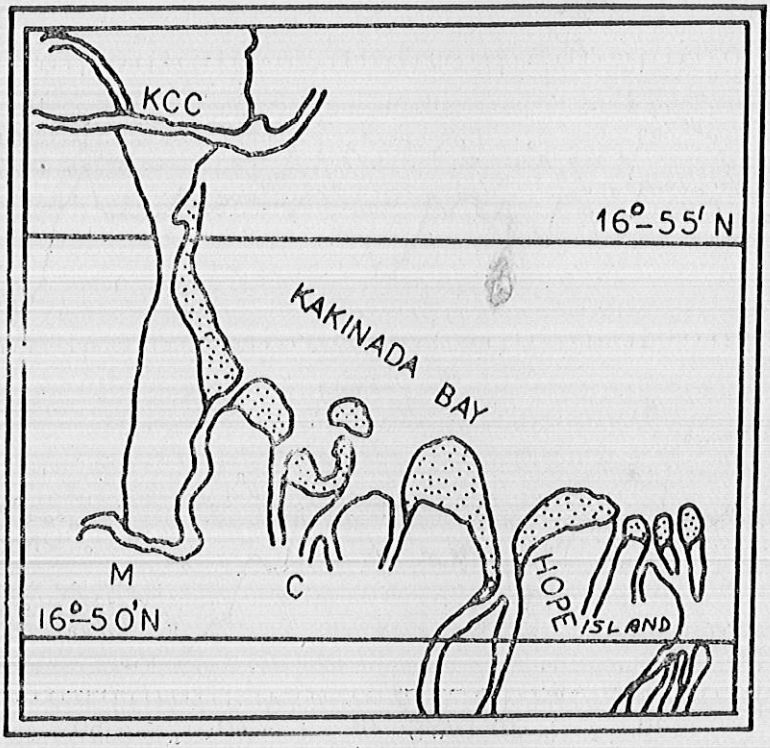

Fig. 1. Showing paddy field drain channels opening in to Kakinada Bay where brood prawns of *M. rosenbergii* occur. (KCC : Kakinada Canal, M: Matlapalem drain, C : Coringa drain.)

During the present study, females in berry which occur in capture fisheries as mentioned earlier, of Matlapalem, Koringa (Fig. 1) and other similar freshwater paddy field drain canals connected to Kakinada Bay (Long. 82° 18' E and Lat. 16°51' N to 17°N) are collected. These are brought alive to shore by fishermen and are purchased by the Department at a rate of Rs. 4-6 per female. Transportation is in live tin carriers, over a distance of 10-20 km to the hatchery. Some eggs (about 20-30%) are lost during the transport or discarded by the female itself. These females are tranferred to freshwater in fibre re-inforced plastic tanks, under aeration. Generally, females

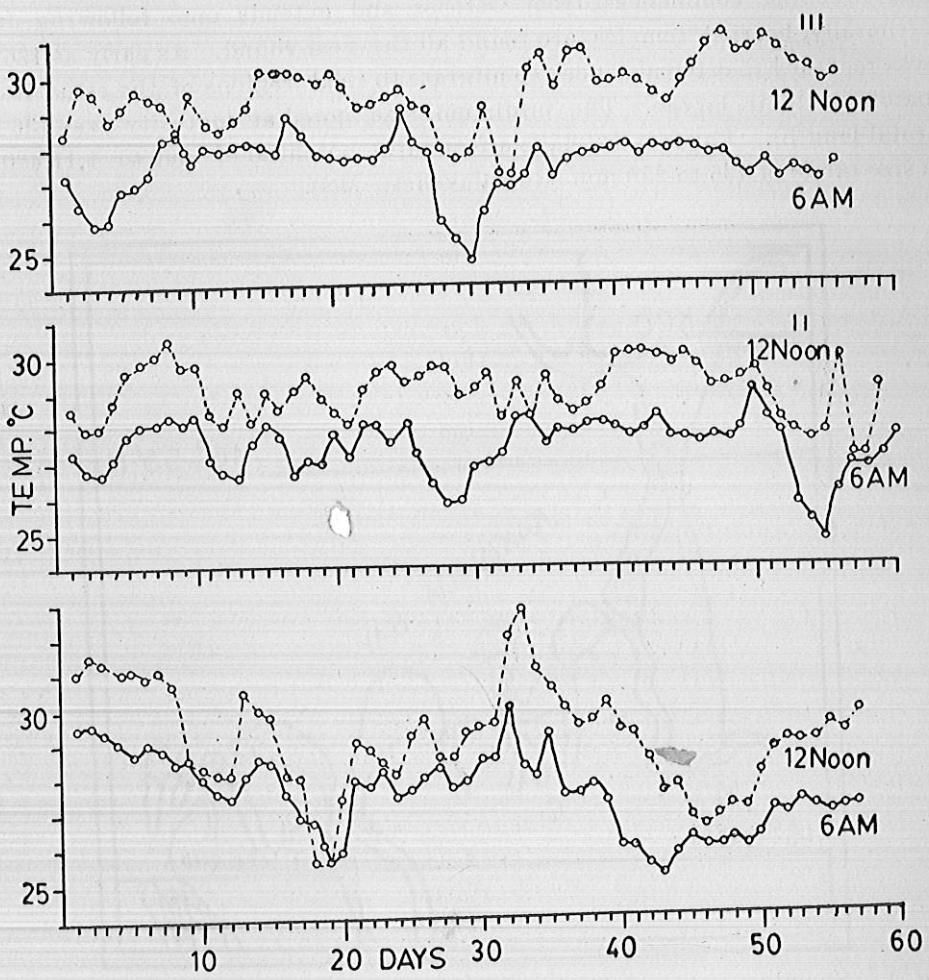

Fig. 2. Temperature profile in the experiments I to III.

with eggs in final stages of embryonic development are chosen, recognised by the colour of the eggs and the black eye spot which gives the egg mass a dark brown-black appearance. By selecting thus, prolonged (15 days or more) maintenance of brood prawns in early embryonic development in tanks, their mortality, loss of eggs and other adverse factors are thus sought to be reduced. Use of natural brood stock is being continued till the first generation of brood stock from post larvae stocked by this Department is ready.

Hatchery and Hatchery Management

Hatchery is located on the coastline along the Kakinada Bay of Andhr

Pradesh. The components of a hatchery are as follows : An asbestos roofed shed 30m long × 10m wide × 6m high is the main hatchery chamber. The walls are partially of brick (upto 1 m) and the remaining open part is made of iron mesh. This mesh has been covered over by removable bamboo mats to protect against the wind and dust in the coastal region. No temperature control measure is used. The equipment consisted of an oil-free electrically operated compressor (5 HP) ; Pipe lines of hard PVC are fixed length-wise along the walls Secondary air control valves are fitted at intervals of 2m along the pipe. Air-lines are taken from these valves to all sections of hatchery.

Rectangular tanks of fibre re-inforced plastic (2m × 1m × 1m), circular plastic-lined pools of various sizes (3′ × 3′, 4′ × 10′) and concrete tanks (2.5′ × 4′) are used for storage of sea water and freshwater, maintenance of brood prawns and for larval rearing.

Water Management

Sea water collected from 2 km off-shore in the Kakinada Bay is transported on the departmental trawlers in repeated sea-trips once in 6 months and stored in the larger plastic pools. This water is aged over a period of one month using oyster shell powder as a buffer. After ageing, stored fresh (municipal tap) water is used for making up to required salinity. The water used in the zoeal rearing tanks is replaced upto 10% once in two days and fully replaced once a week. This used water is then taken to separate container for fresh biological filtration. This water is recycled back into the zoeal tanks after a month, thus eliminating frequent transportation of fresh sea water from off-shore. Thereby transportation costs are also reduced.

In each zoeal tank 3,000 l of water is maintained for each batch of freshly released zoeas.

Currently, attempts are being made to use hyper-saline water from a natural pond adjacent to the hatchery to eliminate the transportation of fresh sea water from off-shore and to introduce new water systems in the hatchery practices.

The water quality parameters regularly monitored at present are the salinity, temperature, pH, and dissolved oxygen.

Larval Rearing and Feed Maintenance

Each brood prawn is transferred 24 to 36 hours prior to hatching to a separate container, where water in low salinity (about 4 ppt) is maintained. When the zoea are released they are siphoned out and transferred to rearing tanks where water with salinity at 15 ppt is kept in readiness. Normally a

single air-line is supplied to each rearing tank containing 30,000-40,000 hatchlings.

The larval moults and full life cycle has been described by Ling (1967 a and 1976 b).

Feed is supplied to the zoea from the third day. Entire feeding schedule is based on tubificid worms. For maintenance of tubificid culture, a shallow ditch (1m wide × 10m length) lined with polythene sheets is maintained outside the hatchery, in the open. Mud is introduced into this ditch and it is then fertilized with dry pig manure. Tubificid worms, collected from drainage outlets of town (municipal) freshwater supply tanks are inoculated into the ditch. A freshwater tank maintained at an elevation at one and of the ditch keeps a slow drip type water flow, thereby maintaining continuous flow-through freshwater that is essential for the growth and multiplication of the worms. The excess water flows out from the other end of the ditch. The worms soon multiply and occupy the entire length of the ditch. Once in 3 months the ditch is emptied and a fresh culture is started.

Tubificid worms are taken out for each day's requirement, washed in clean freshwater to remove the mud and other organic load. They are chopped and sieved through mesh of 40 microns and 60 microns for supply to early zoeal stages, the mesh size increasing with growth of the zoea. Each time about 2 to 3 ml of feed are supplied to each larval tank twice to three times a day, as per the density of the stock. Before use the feed is dipped in 0.1% copper sulphate solution as a prophylactic measure.

An *Artemia* culture is also maintained in outdoor tanks (3′ × 3′) for continuous culture. Brine mixed with sea water is used in the tanks. Pig manure is introduced to maintain diatom culture in the pools. No aeration is done. Except for one attempt, Artemia was however, not used as a larval feed because of the high quantities required for feeding each batch of zoea. Further, the tubificid is readily accepted by the zoea.

For the present the hatchery programme is conducted in 4 to 6 tanks only with small number or berried females.

Culture Trials

Pond construction :

The current trends in construction of freshwater ponds, in general, in Andhra Pradesh are described below :

Construction of ponds in extensive scale by private enterpreneurs is of recent origin, particularly, in two districts of Andhra Pradesh.

Water resource being a primary consideration, a large inland swamp call-

ed Kolleru Lake has been first developed by the Department of Fisheries Government of Andhra Pradesh. The lake recedes in nonmonsoon months to + 3 to + 1 flood-larval contours while in monsoon it rises to + 7 to + 10 contours (Rajyalakshmi, 1972). A series of 114 tanks have been excavated to a uniform depth of 1m as 10 acre and 40 acre pond units in the + 2 contour levels in many cases to protect the pond in flood times. Farmers adopted different methods, excavating only 30% of the pond area to form peripheral trenches leaving a central flat plateau where no excavation is done. The depth in trenches was 1.5 m such that a level of 2′ was present on the central area. The general depth, a however, varied from 1m to 1.5m from summer to monsoon. The pond sizes vary from 10-acre units to 100 acre units. In other regions of the state, ponds are excavated based on the above general principles, on lands adjacent to the extensive irrigation canal system of Rivers Godavari and Krishna. The total pond acreages are small, from 20 acres to 60 acres, each pond unit having 1—1.5 ha.

In all the above excavations, top soil has been removed. Pond slopes are maintained at 1:3 ratio and berm of 1m width is made between the pond slope and water edge. Compacting of pond walls is done.

Only one in-let pipe of concrete is maintained with velon mesh screens, the latter placed at one or two places along its length. The latest designs of water management incorporate pumping water into pipelines elevated to the bund level; the in-let was also placed at an elevation so that water can cascade down and provide flow as well as oxygenation. No out-let is provided for in any of the ponds, water being pumped out whenever required. Wind circulation helps to keep aeration, ponds being exposed with no shading of trees, or any such obstruction.

Water is drawn-in into the ponds in the month of June. During normal monsoon (rainy) season, water is not replenished upto October. Thereafter, once in a month water is replenished to cover any loss by evaporation.

The ponds are excavated generally in alluvial black loam soils. Coastal ponds have occasional patches of sand.

The characters of pond used for experiments 1-4 are shown in Table 1. One is a coastal pond, all the other 3 are located 10-20 km inland. All are fed by irrigation canal water. Despite this in ponds in the experiments 3 and 4 bottom waters are found to be saline.

Pond Preparation, Stocking and other Management

Pond Preparation :

The fertilizer treatment consists of addition of cowdung and lime or urea

Table 1. Results of Hatchery Experiments

Experiment No	Size of brood female (mm)	No./hatchlings released/Date of release	Date first release of post larva/ final release	Survival %	Water parameters in zoeal tanks		
					Average salinity (ppt)	Average DO (ppm)	Temperature range °C
1	140	30,000	2.8.82	5.9	15	8.4	30-32.8
		1-7-82	26.8.82				*25
2	150	40,000	2.10.82	4.8	15	8.0	30.5
		28.8.82	25.10.82				*24.6
3	160	50,000	4.11.82	5.6	15	8.1	25-30.8
		21.9.82	15.11.82				*24.8
4	158	50,000	.....mortality due to fungal incidence				24-26.8
5	160	55,000	1.12.82	2.0	15		18-22.4

*Dip in temperature caused by cyclonic storm.

and superphosphate plus lime in one major instalment of 25kg/pond before letting in water. The ponds are stocked one week later. Thereafter, fertilizer is added in water once a month or 15 days depending on the growth of phytoplankton or change in colour of the water. If water turns dark green, then partial exchange of water is done followed by addition of lime. The latter is meant to keep the pond clean, buffer the pH and raise the oxygen level.

The predators found in ponds are snakes, crabs, murrels and occasionally, larger cat fish such as *Wallago attu*. Constant attempts are made to remove them in sample netting.

Stocking :

Seven to ten days old post-larvae, at an average size of 8mm/12-15mg are stocked directly in experimental culture ponds for want of separate nursery tanks. For any future programme nursery tanks have to be extensively maintained.

Stocking is also done at a rate of 20,000/ha, on the basis of experience gained in experiments on culture of *Macrobrachium malcolmsonii* (Rajyalakshmi *et al.*, 1982). Post-larvae are transported in oxygen-filled polythene bags at a rate of 500 per 3 litres of water. Generally, packing is done either early in the morning or late in the evening as a measure of protection against rising temperatures during day time.

Feeding :

Supplemental feeding is given in the form of food balls placed in trays and arranged in several places in the pond particularly at the shallow edges.

Rice polish or rice bran is the base feed. Meat of freshwater snail, *Pila globosa* or trash fish is mixed with it. Feed is given at 5% of biomass in the early growth phase and 3% at later phase. In the farmers ponds this schedule is not strictly followed.

Sampling :

Sampling is done once in a month using cast net or by hand-picking. Because of heavy weed growth operation of nets is made difficult. Therefore hand-picking of prawns is done for taking length/weight measurement.

As in all other prawn ponds either of *(Macrobrachium malcolmsonii* or *Penaeus monodon)*, it is found better to pump out all water for final harvesting at the end of 6 months when the culture trials are completed.

RESULTS

Hatchery Experiments

As stated, the work has been started in 1982 and the results of 4 to 5 trials conducted in hatchery are shown in Table 2. The Table 2 also shows the water quality parameters of each experiment. About 30,000 to 50,000 hatchlings are released per female in sizes of 140 to 160 mm, because of the 20-30% egg loss noticed during transportation. Each rearing cycle has taken a period of 31-55 days depending on the date of first metamorphosis to post-larvas. Final metamorphosis of the complete batch of post-larvae took a period of 3 weeks.

At a temperature range of 30-32.6°C, the first post-larvae emerged on 31st day. At 28-30.8°C a longer time of 30-36 days was taken, the length of rearing cycle increasing with further decline in temperature. Survival was 100% upto 6 to 7 days of rearing cycle. Thereafter, heavy mortality was noticed. During all the first 3 experiments, around 15th to 30th day of metamorphosis, a sudden cyclonic storm threatened the coastline with drastic fall in temperature (Fig. 2 . The temperature decline was 2 to 3°C of the average daily range. This resulted in heavy mortality of more than 50%. The final survival was thus between 4.82 to 5.9% only.

In three batches viz., a period of 120 days, about 8,000 post-larvae was produced. In the 4th experiment about 80% mortality resulted after a sudden incidence of fungal attack followed by multiplication of cope-pods in the tank. This batch was totally discarded to prevent further contamination.

Table 2. Characteristics of Ponds used In Culture Experiments

Experiment No	Location/number of pond	Pond size/ depth	Water resource	Water/quality parameters				Fertilization	Stocking rate	Remarks/ Feeds
				Salinity	pH	Temperature (°C)	DO_2 ppm			
1.	Government Farm, 20 km from Hatchery / one pond	0.19 ha 1m—1.25m	Irrigation Canal	...	7.8—9.2	30—18	6—8	Cowdung and lime		Weed-choked Manual removal from time to time
2.	Private sugar factory farm 12 km from hatchery/ 4 ponds	0.02 ha 1m	ground water and rain water	...	7.5—8.9	30—18	5—8	,,		Feed of rice polish+trash fish or Pila meat. Weeds present Rice bran
3.	Private coastal farm 15 km from hatchery/ 1 pond	0.02 ha 1.5m	Irrigation canal	Traces —2ppt because of ground seepage	7.8—9.0	30—18	5—6	,,	20,000/ha	Free of weeds Rice bran Free of weeds Rice bran
4.	Private farm, 15 km from hatchery / one pond	0.02 ha 1m	,,	5—7 ppt bicause of ground seepage	7.5—8.5	26—18	5—8	,,		

A fifth batch began to be reared in the winter months of December to January (Temperature 22.4°C to 18°C) has shown high mortality at each moulting after the 10th day. The zoea have grown at a slow rate. Despite moulting, growth was not evident during the mid-phase *i.e.*, 15 to 20 days of rearing. Use of thermostats in the rearing tanks has raised the temperature to 0.5°C and resulted in some improvement in arresting mortality. This batch took 45 days for the first emergence of post-larvae.

As the post-larvae emerged they were acclimatized to freshwater over a 3 day period in a slow-drip flow and after one week of acclimatization and growth they are taken out and marketed or stocked in culture ponds. The post larvae showed high rate of cannibalism if kept for longer than 10 days in the rearing pools in the hatchery, the loss ranging from 8 to 10% in 7 to 10 days.

An interesting fact that was observed in all the experiments was that even from 10 to 15th day of rearing, some larvae showed faster growth rates and these metamorphosed in advance of others. These early fast growing forms when stocked in culture ponds turned out to be males that have grown to uniform sizes.

Culture In Grow-out Ponds

The details of size at stocking, density, grow-out duration ultimate growth and survival are given in Table 3.

Experiment 1 :

This was the first experiment of the Department in a single large pond of 0.02 ha (in a 28-acre farm). The pond was prepared by use of cow-dung and lime (burnt shell powder) at the rate of 25 kg/ha each. De-weeding of the pond was done prior to fertilization. Artificial hide-outs were arranged by way of hanging netting materials. Feed was given in basket-trays. A trial batch of 1,000 ten-day old post larva (10-12 mm in total length) were released into the ponds on August 21st. Monthly rate of growth was recorded by sampling (Table 3).

The average growth was 111.1 mm/15.27g (2nd month 50 days after stocking), 153.4mm/40.6 g (3rd month, and 161.5 mm/44.8 g (4th month). The best growth period tallied with late monsoon (August) and winter season (November) for this region. Water temperature ranged from 30.3 C to 18.0°C and pH 7.8 to 9.2.

As stated earlier, there was a distinct size difference in some of the zoea which metamorphosed early. The post-larvae stocked in this pond are the early-metamorphosed zoea of the first laboratory experiment. The sampled

Table 3. Details of Culture Experiments

Experiment No.	Date of stocking	Stocking density (Nos/ha)	Size at stocking (mm)	Growth			Estimated survival (%)	Male/Female ratio (%)	Remarks
				2nd month (mm/g)	3rd month (mm/g)	4th month (mm/g).			
1.	21.8.1982	20,000	10-12	111.1/15.27	153.4/40.6	161.5/44.8	70	75.25	
2.	3.11.1982	20,000	8	105.8/9.67	Experiment continuing		60	56.4/43.6	Slow growth rate
3.	2.11.1982	20,000	8	50/1.9	Experiment continuing		Not estimated due to deep water level	—	Date of stocking being in winter months of November in saline ponds
4.	5.11.1982	20,000	8	56/2.5	Experiment continuing		Not estimated	—	

stock consisted of over 70% of males in the population and probably this fact is the reason for their higher growth at each monthly sampling as compared to the following experiment.

Experiment 2 :

Experiment 2 was conducted in farmers' (sugarcane factory) ponds. Four similar-sized ponds excavated in soils of old factory ash and other waste overlaid by soil. Weeds have grown in the pond.

Post-larvae at an average size of 8 mm were stocked at a density of 20,000 /ha in each pond. These post-larvae were the late-metamorphosed first batch in the laboratory experiment. The average growth of prawn of all the 4 ponds from an initial size of 8 mm/6 mg was 99.4 mm/0.9g (1st month), 105.8mm/ 9.67g (2nd month). Survival is found to be 20% only. As compared to experiment 1, the growth rate was quite low.

The batch consisted mostly of females.

Experiments 3 and 4 :

Experiments 3 and 4 are in small nursery ponds 0.02 ha in size, to study the adaptation and growth in low-salinity waters. In these experiments the tiger prawn, *Penaeus monodon* and *Macrobrachium rosenbergii* were stocked together, *Penaeus monodon* grew from 30 mm (initial size) to 80 mm/4 5 g in one month. Survival was also good. *Macrobrachium rosenbergii* showed a growth increase of 56 mm/2.5 g in a period of 30 days after stocking.

The saline ground water in these ponds has seeped in from the surrounding regions which are swampy in nature occasionally submerged by tidal waters.

DISCUSSION AND CONCLUSIONS

The main aim of the study and presentation of this paper is to bring out the great potential that exists for culture of the giant freshwater prawn in India using available freshwater farm resources. The experimental studies conducted on hatchery rearing and field culture though preliminary in nature, strengthen the observations simultaneously being made by the other Research Institutes in India. A wide range of information is available on the biology of the species sampled from the capture fisheries in India. The extensive studies particularly in Hawaii clearly show that adoption of extensive *Macrobrachium rosenbergii* culture practices in the extensive pond systems of Andhra Pradesh might be very economic.

Experimental hatchery, modest in size has been started by Central Inland Fisheries Research Institute at Kakinada in 1976 (Anon, 1976). Since then

the production was reported to be in the range of 10,000 to 0.1 million juveniles per year. In 1982, the present department also took up this study producing 8,000 post-larvae in small four to five tank units in a period of 4 to 4½ months. Both these hatcheries are indoor semi-intensive type using filtered, aged sea water, aeration and live feeds of tubificid worms. The rearing containers are mainly plastic and concrete tanks.

No private hatcheries have yet taken up seed production operation since farmers are yet to get into the culture in a large way. However, the unit economics of a small hatchery (Table 4) indicates that such an enterprise can be considered beneficial to an enterpreneur.

The entire hatchery production is based on single feed viz., tubificid worms. The worms, collected from drainage canals of the city *i.e.*, drainage from drinking water system, are grown and multiplied in shallow earthen ditches. The ditch has a mud base fertilized with pig manure. A flowing water arrangement keep the worms alive and multiply. Brousing of larvae on diatoms which grow on walls of the plastic pools is incidental and no attempts are made to supply cultivated feeds of diatoms. Any other feed such as nauplii of *Artemia salina* could be highly cost-prohibitive.

The survival, growth and ultimate yield of post-larvae for experiment have indicated great potential for intensification of the hatchery practices. The physico-chemical water parameters, particularly temperature, is found to be a critical factor. Generally, Kakinada area of Andhra Pradesh has an almost equitable temperature range throughout the year with two exceptions. One critical period occurs in May-June in the peak summer months with the temperatures rising up to 44°C in some days. The 2nd critical period occurs in the months of September/October when cyclonic storms and gales occur resulting in drastic dip in temperature to 22-25°C. The average optimal range is at 28 C to 31°C in these studies. High mortality was recorded (Table 1) below and above this range of temperature. Temperature controls might be necessary at critical times, if large scale mortality is to be prevented in the future hatchery programme.

Use of fertilizers and feeds, their efficacy in extensive ponds are to be studied further. Adopting the practices advocated by research institutes in composite culture, the prawn ponds are also fertilized with cow-dung, superphosphate and urea at specified rates and dosages. In studies conducted on rearing *Macrobrachium malcolmsonii* it was observed that use of fertilizers/manures resulted in thick algal blooms (Rajyalakshmi, *et al.*, 1983). On the other hand, chopped meat of freshwater snail *Pila globosa* resulted in good acceptance by the prawns and no algal blooms occured in the ponds. Growth was also quite

Table 4. Unit Economics of *Macrobrachium rosenbergii* Seed Production

One Unit	:	3 Persons, 8 tanks
Breeders	:	16 Nos.
Period of culture	:	45 days
Seed rearing per tank	:	50 thousand
Final post larvae per tank	:	4,000 (Average)
		4.000 × 8 = 32,000 Nos.
Cost :		
a. Cost of 8 tanks (Cement)	:	Rs. 2400 Capital cost 2,400/-
Variable costs :		
b. Cost of labour (3 × Rs. 7.50 × 45 days)	:	1080
c. Cost of brood prawns (16 × Rs. 5.00)	:	80
d. Transportation of seawater/brood prawn etc.	:	200
e. Cost of electric current	:	75
f. Cost of shell lime, chemicals etc.	:	75
		1510 Variable cost 1,510/-
Returns :		
a. Yield in No. 32,000 × Rs. 75 (per thousand)		= Rs. 2,400/-
Net income per each production period		= Rs. 900/-

(Note :—Cost of shed not included)

favourable. Because of the use of 2nd pair of chelipeds by the prawns for catching food and transferring it to the mouth directly, use of feed pellets might be more suitable in freshwater prawn culture.

A great amount of study still needs to be done on factors such as optimal depth in the prawn ponds, flow-in and flow-out of water, the frequency of replenishment or exchange. Studies are also to be conducted on stocking and harvesting factors so that, as seen in the case of culture of *Macrobrachium malcolmsoni*, a pattern of repeated harvesting with two to three stockings in a year can be adopted based on the short growing season of the species to optimise water utilization and production.

In the years 1976 to 1982 private enterpreneurs in Andhra Pradesh have gone in for composite fish farming in a very extensive way. At this date the

total acreage under private farming ventures might be around 1,500 ha. The farms constructed by Government of Andhra Pradesh and distributed to Fisheries Cooperatives (50 to 100 fishermen for management of 16 ha ponds and 2 fishermen for the newly excavated 1-ha ponds cover another 200 ha. All in all, the developments in this field are very fast. So far, the composite fish culture practices advocated by the National Institutes (Indian Council of Agricultural Research) are followed (Rajyalakshmi, 1982. Only one marketing channel is open for the farmers which is centralised in Calcutta city in North-Eastern India. Conditions are now favourable for diversification of culture, introducing species such as *Macrobrachium rosenbergii* and *Macrobrachium malcolmsonii* into the composite culture or developing a separate strategy for monoculture. Techniques of freshwater prawn culture have been developed in India (Rajyalakshmi, *et al.*, 1983) and the techniques adopted in the extensive grow-out systems of *Macrobrachium rosenbergii* in Hawaii (Fujimara and Okamoto, 1976, Hanson and Goodwin, 1977) can be adopted suitably modified for conditions in India. Some progressive farmers have begun to adopt this culture as an experimental measure. With the seed constraint removed, the switch-over to extensive farming of prawn could become more rapid.

REFERENCES

Anon, (1975). Annual Report of the Central Inland Fisheries Research Institute, Barrackpore (Project 6 .

Anon, (1976). Ibid

Chopra, B.N., (1943). Prawn Fisheries in India. *Curr. Sci.* **12**(2) : 71

Forster, J.R.M , Wickins, J.F. Prawn Culture in the United Kingdom the status and p tential. *Lab Leafl. Fish. Lab. Lowestoft* (New series) ; 27-32.

Fujimura. T. (1966) Notes on the development of a practical mass culturing technique of the prawn *Macrobrachium rosenbergii*. Indo-pacific Fisheries council (IPFC) of FAO Regional Office for Asia and Far East, Bangkok, Thailand, 12th session.

Fujimura, T., and Okomoto, H. (1970). Notes on progress made in developing a mass culturing technique for *Macrobrachium rosenbergii* in Hawaii. FAO Indo-Pacific Fisheries Council, 14th session, Bangkok Thailand, 18-27 Nov. 1970. 18 pp (mimeo)

Fujimoto, M., Fujimura, T. and Kato, K. (1977). Pond grow out systems Chapter VI. *In* (Editors) J.A. Hanson and H.L. Goodwin . Shrimp and prawn farming in Western Hemisphere State of the Art Reviews and status. Dowden, Hutchinson and Ross. Inc., Stroudsburg. Pennsylvania.

Hanson, J.A. and Goodwin, H.L. (1977). Shrimp and prawn farming in western Hemisphere. State of Art Reviews and Status. Dowden, Hutchinson and Ross., Inc. Stroudsburg, Pennsylvania.

Ibrahim, K.H. (1962). Observations on the fishery and biology of the freshwater prawn *Macrobrachium malcolmsonii* Milne Edwards of River Godavari. *Indian J. Fish* **9A**(2) : 433-467.

John, M.C. (1957). Bionomics and life history of *Macrobrachium rosenbergi* de Man. *Bull.*

Cen. Res. Inst. Univ. Trivandrum. Ser. C. **5** (1) : 93-102.

Ling, S.W. (1967). General biology and development of *Macrobrachium rosenbergii*. *FAO Fisheries Repor's* (57) vol. 3 : 589-606. Proceedings World Scientific Conference on Biology and culture of shrimps and prawns, Mexico, 12-21 June.

Ling, S.W. (1967 b). Methods of rearing and culturing *Macrobrachium rosenbergii*. *FAO Fisheries Reports* (5M) Vol. 3 : 589-619 proceedings of the World Scientific Conference on biology and culture of shrimps and prawns, Mexico city, Mexico, 12-24 June.

Rajyalakshmi, T. (1961). Studies on maturation and breeding in some estuarine Palaemonid prawns. *Proceedings of the National Institute of Science, India*. 27, B 4 : 179-188.

Rajyalakshmi, T. (1968). Try prawns in tanks and inland waters. *Indian Fmg.* Nov : 37-43

Rajyalakshmi, T. and Ranadhir, M. (1969). The commercial prawn *Macrobrachium malcolmsonii* (H. Milne Edwards) of River Godavari, a discussion on trends and characteristics of the population during 1963-66. *FAO Fisheries Reports* **57**(3) : 903-921. Proceedings of the World Conference on the Biology and Culture of Shrimps and Prawns. Mexico city. Mexico 12-21 June.

Rajyalakshmi, T. (1975). Environmental ecology of *Macrobrachium rosenbergii Macrobrachium malcolmsonii* and *Metapenaeus monoceros* in certain drain channels opening into Kakinada Bay. *Bull. Dept. of Mar. Sci.*, **VII** (2) : 285-292.

Rajyalakshmi, T. (1979). The role of *Macrobrachium* species in freshwater aquaculture systems. Abstract P. 119. *In* : Symposium on Inland Aquaculture 8–14 February, *Central Inland Fisheries Research Institute Barrackpore.*

Rajyalakshmi, T., Rao, L.A , Rama Raju, T.S., SubbaRao, R. and Bose, P S. (in Press) Experiments in culture of *Macrobrachium malcolmsonii* Inland Aquaculture. *Central Inland Fisheries Research Institute, Barrackpore.*

Rajyalakshmi, T. (1981). Scope and prospects of Integrated fish culture in Andhra Prade h -a case study. *Lecture In* : Summer Institute on Farming Systems integrating Agriculture, Live Stock and Fish Culture, July 6-Aug 4. *Central Inland Fisheries Research Institute, Barrackpore, India.*

Rajyalakshmi, T. (1982). "Fisheries in Andhra Pradesh". Chapter in "Agriculture in Andhra Pradesh" vol. I. *The Society of Scientists for advancement of Agricultural (ED) K. Bhaskaram.*

Rajyalakshmi, T Ramachandra Reddy, O., Appa Rao, A. and Ramakrishna, R. (1983). Growth and production of Riverine prawn of India, *Macrobrachium malcolmsonii* H. Milne Edwards in pond culture, Andhra Pradesh, India. *The World Mariculture Society, 1982 sessions Washington DC.* Jan. 10-13.

Rajyalaksmi, T. (MS) "Contributions to the knowledge of the biology of some estuarine prawns" unpublished Doctoral thesis (Andhra University, Waltair) 1976.

Raman, K. (1967). Observation on the fishery and biology of the freshwater prawn *Macrobrachium rosenbergii* (de Man). *Proc. symp. Crustacea. Mar. Biol. Assn. India.* Part III. 649-669.

Rao, Mallikarjuna. (1967). Studies on the biology of *Macrobrachium rosenbergii* (de Man) of the Hooghly estuary with notes on its fishery. *Proc. Nat. Inst. Sci.* India 33 B: 252-279.

Wickens, J.F. and Beard, T.W. (1978). Prawn culture research. Ministry of Agricultural, Fisheries and Food. *Lab-Leaft., Lowestoft.* **42** : 1-42.